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ABSTRACT

The factors underlying memory performance in learning are shown to be affected by strategic processing and by automatic processing. Strategic processing is under the conscious control and effort of the learner while automatic processing is dependent on the strength of associations between new concepts and known concepts in a given domain. Increases in the subject's knowledge base are discussed in relation to increases in performance when grade school children and a sample of college students were given standard free recall instructions and a categorization strategy, and were inhibited by the use of a repetition strategy. A second experiment with second and fifth grade children varied memory instructions and manipulated the knowledge factor with high- and medium-frequency generated item lists. Performance increases through increased knowledge are shown to be mediated through automatic rather than strategic processing. The interaction of strategies, knowledge and performance are discussed, and automatic processing by children is compared to strategic processing by adults. The relative contributions of the factors are shown to need further distinction. (Author/CM)

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Facilitation of Performance Through Increased Knowledge: Attentional or Automatic?

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For a number of years, psychologists have been trying to specify the factors underlying differences in memory performance. Why is it that adults or college students are able to memorize material better than school-age children? Why does an expert in a given domain memorize material from that domain better than a novice?

While a number of factors are probably involved, one factor has to do with the intelligent structuring and storage of the input material (Flavell, 1971). Memory performance is correlated with the ability of the learner to organize the to-be-learned material or the ability to make the material meaningful (Bransford, Stein, Shelton, and Owings, 1980). This view implies that the learner has to take an active role in the memorization process in order for good memory performance to occur.

In fact, one of the most common explanations of children's poor memory performance relative to college students is the deficient use of strategic processing. Flavell (1970) has stated that whenever a task which requires strategic processing is used, developmental differences in performance will be found. Let me at this point define what I mean by strategic processing. I am defining strategic processing so that it is equivalent with what has been termed controlled processing. The main characteristics of such processing is that it is first, under the conscious control of the learner; the learner can decide when or when not to use a given strategy, and secondly, it takes effort to apply the strategy.

One such strategy is rehearsal. In free recall learning tasks, children under the age of 7 or 8 years either do not engage in rehearsal at all (Flavell, Beach, & Chimsky, 1966), or if they do, they tend to

rehearse each item separately; in isolation from the other material to be remembered (Ornstein & Naus, 1978). Related to the lack of this strategy, young children do not realize the value of grouping items on the basis of similarities or category membership as an aid to free recall learning (Ornstein & Corsale, 1979). When young children are given an opportunity to group items from common categories into piles for the specific purpose of helping them to remember, they rarely categorize the items. Rather, they make idiosyncratic piles (Moely, Olson, Hawles, and Flavell, 1969). This result is found even though it has been shown that young children do sort items by categories if the items are familiar members of well known categories (e.g. Worden, Mandler, & Chang, 1978).

While the factor of strategic processing seems to be important in explaining age-related differences in performance, a second factor, that of content knowledge, or the amount of knowledge one has within a given domain, also has a large effect on performance. For example, Chi (1978) found that children who were experts at chess recalled significantly more chess positions and grouped items into larger chunks than adults who were novices. This finding was reversed however, when the same subjects were asked to memorize a list of digits.

Although the factor of content knowledge has been shown to affect performance dramatically, it must be emphasized that little information is available as to how this improvement is mediated. What are the children doing in the case where they are asked to memorize chess positions that they are not doing when memorizing digits?

There has been a tendency in the literature to think of these two

factors, strategies and content knowledge, as being separable, distinct and non-interacting. A common example of this view is the training study. In such a study, children are shown how to use a given strategy, one which is supposedly being used by the successful learner, and then instructed to use it. The purpose of this type of study is to see if one could improve performance merely by manipulating strategic processing. Unfortunately, when such instructions are given, rarely are developmental differences in performance removed.

The underlying assumption is that the child has the relevant knowledge needed to perform the strategy and prompting the child to use the strategy should remove the developmental differences. The possibility that there are differences between children and adults in terms of accessibility of the relevant knowledge is not taken into account. Children, through the unfortunate experience of not being around as long as adults, not only have less knowledge about different strategies but also have much less knowledge overall about most concepts and their interrelationships. This should have an effect on the accessibility of the relevant information and differences in accessibility might affect how well one can use a given strategy.

We must return then to the question of how an increase in content knowledge mediates increases in performance. What are the types of processes that can be influenced by increased knowledge? How does increased knowledge change the representation of a domain?

Theories of semantic memory have suggested that knowledge is stored in terms of an associative net. Concepts are seen as being stored as the nodes of the net, while relations between concepts serve as

associative links. Ignoring for the moment the possibility of a total reorganization of the knowledge base, increased knowledge in a given domain can affect one's representation in two ways. First, through the accumulation of new knowledge, new links could be formed between concepts. One might learn that a concept has properties that were not known before. For example, one might discover that the moon is in fact made of green cheese. Thus, a new node and associative link would be added to your knowledge about the moon. Also, relations between different concepts can be derived and so new associative links might be formed. In both these examples, new information is added to existing knowledge.

Secondly, increased knowledge might strengthen the existing links. This effect probably occurs as a byproduct of access. As two concepts continually get accessed together, the associations between these concepts strengthen. For example, the child might realize that a flute is a musical instrument, but not having accessed that information very often, the associative link might be weak. Upon continued access to that information, the strength of that associative link increases. In turn, the increased strength leads to easier accessibility of that knowledge. Thus, knowledge can be characterized along a continuum of accessibility, with some information being readily accessible, and other information being completely inaccessible.

The question then becomes, how does increased experience in a given domain affect performance? I have two hypotheses as to how this might occur. The first is that greater knowledge increases the strength of associations over a threshold point so the learner is then able to apply

a certain strategy. In other words, in order for a given strategy to be employed, knowledge relevant to that strategy must be somewhat accessible. For example, no-one would expect a subject to categorically organize a list of items if they had no knowledge of the categorical structure of the list. That knowledge is not available. Or, subjects might have the specific knowledge needed to apply a given strategy but fail to do so; they might not try to access the information due to its low level of activation. So the learner might not notice the categorical structure of the list and hence not try to organize the items by categories. Thus, in order for a strategy to be used, accessibility to relevant knowledge must be above a threshold point. Greater content knowledge increases performance because it allows easier application of a given strategy. A related hypothesis is that the more accessible the information the easier it is to apply the strategy.

The second hypothesis is that strong associations, which are a byproduct of the increased knowledge, are being automatically activated. The idea that activation of a given concept automatically activates related concepts is not new. Collins and Loftus (1975) hypothesized that when a word is encountered, the concept corresponding to it is activated. Upon activation of a given concept, activation also spreads from that concept to other concepts related to it. The amount of spreading activation depends on the strength of the associations between concepts, with stronger associations leading to stronger activations. This process is carried out automatically and is not under the conscious control of the person.

Thus, the associations between items might be so strong that access

to the relationships between the items occurs automatically. An example of this type of processing would be the case of a free recall task in which the items are taken from a limited set of common categories. In such a list, the subject might first see the word dog and then later in the list see the word cat. Upon viewing the word cat, the association between the words cat and dog might be so strong, that the word dog automatically pops into consciousness, regardless of any strategic processing the individual might be doing.

The underlying distinction between these two hypotheses is in terms of the types of processing that subjects do that would lead to better memory performance. In the first hypothesis, performance increases because of increased use of an effective strategy. This means that the learner is consciously trying to apply or is having an easier time applying a strategy when relevant knowledge is more accessible. Performance is increasing because of something the learner is actively trying to do. The second hypothesis attributes performance increases to automatic processing. Relevant knowledge, that makes the memorization task easier, is becoming available, not because of anything the learner is actively trying to do, but because that knowledge is automatically activated. Automatic processing, unlike that of strategic processing, is not under the conscious control of the learner; it will occur no matter what the learner is doing given that the meanings of the terms gets activated. Also, because it is not under the conscious control of the learner it take very little of no effort for this processing to occur.

We can use this distinction between automatic and strategic pro-

cessing to investigate how increases in the knowledge base mediate increases in performance. To do so let me first present a basic research design and some results commonly found. The task is a free recall task in which all the items are taken from a small subset of semantic categories and the subjects are a sample of grade school children and a sample of college students. In the first condition subjects are given standard free recall instructions. In such a condition developmental differences will be found in the amount of recall and clustering. College students will tend to group items from the same category together in recall. In the second condition, we instruct the subjects about a good strategy, that of categorization, and tell them to use it. The college student, supposedly already uses this strategy and so the instructions should have little or no effect on performance. Children, however, are supposedly deficient in strategic processing and so instructing then to use a categorization strategy should increase recall. In the third condition, we try to inhibit the use of the efficient strategy by imposing the use of a less efficient strategy (one often thought to be used by the younger children). If it requires effort on the part of the learner to try to categorize the items, then imposing another strategy such as repeating the items over and over again, such inhibit the categorization process. It is hard to perform two things at one time. Thus, in this condition, college students performance should decrease; they can't be as strategic as they normally are. However, given that children are not trying to categorize the list, imposing the use of an inefficient strategy should have little effect on performance.

Now, all these results can be found in the available literature and

in fact I have replicated them all in my own research. But to make the picture a little more complicated, what would we expect if we added a knowledge manipulation to the above design, so that we now have two lists of items, one consisting of very familiar items and one consisting of less familiar items? We know from past research, that subjects remember more of better known materials than of lesser known materials.

However, should we be able to inhibit the performance increases brought about by the use of well known stimulus material? This question is easiest addressed by looking at children's performance since they are supposedly non-strategic. If performance is increasing because the child is now trying to categorize the material, then instructing the child to repeat the items over and over again should once again bring performance down. Alternately, if increases in performance are being mediated by the automatic activation of relations among the items, then performance should not decrease when the children are instructed to use the inefficient strategy. This type of processing is relatively independent of the type of strategy being employed.

The second question is, what is the relative effect of the knowledge manipulation in terms of instructing children to use the categorization strategy? On the basis of the past literature, we might expect that instructing children to try to categorize the items should facilitate performance equally with both lists. Alternately, does the ability to apply a given strategy vary as a function of how accessible that knowledge is?

Let me briefly tell you of some results from an experiment I recently conducted which was designed to address these questions. The

first factor was that of memory instructions. Subjects were given one of the three types of memory instructions mentioned before; standard, categorization, and repetition. The second factor was one of knowledge. Based on the free generation norms of Posnansky (1973) I generated two lists of words. The first list was a high knowledge list, consisting of items that were most frequently generated when a category label was given. The second list was a medium knowledge list consisting of items taken from the middle of the generation norms for each category. The two lists are presented in Table 1.

I would like to stress two points at this time. The first is that all the items were relatively well known to all the children. There was no attempt when compiling the stimulus materials to take items which were infrequently generated. This is why the second list is called a medium knowledge list as opposed to a low knowledge list. Secondly, I am not really interested in whether children will recall more from the high knowledge list than from the medium knowledge list. We already have a pretty good idea that they will. Rather, I am interested in the interaction between the knowledge manipulation and the strategy manipulation. For this reason, I only used the free generation norms as an index of relative knowledge, and not to say anything specific about category generation norms and memory.

The subject population consisted of samples of 36 second and fifth graders. The Memory Instructions factor was a between subjects factor and the Knowledge factor was a within-subjects factor. There were 12 data points for each cell.

The design and the results, presented in terms of the percentage of

items recalled, are presented in Table 2. I will briefly review the data relevant to the questions I have raised. As expected, there was a significant main effect of the knowledge factor. Subjects in both age groups recalled more items from the high knowledge list than from the medium knowledge list. Are we then able to inhibit the performance increase by making sure that the children are using an inefficient strategy, such as, repeating the items over and over again? The answer seems to be no. Instructing the children to repeat the items over and over again had no significant effect on performance in comparison to subjects in the standard memory condition in either grade. This effect did not vary with either type of list for either grade. These findings are in marked contrast with those found with adults, which show that the strategy of rote repetition significantly decreases memory performance. At this point, although there are alternate explanations, there seems to be some support to show that increases in performance through increased knowledge are being mediated through automatic processing rather than strategic processing.

On the other hand, we also know that strategic processing also contributes to good performance. What was the effect of instructing the children to consciously try to categorize the list? Performance improved significantly in both age groups when subjects were given categorization instructions as compared to the standard and repetition memory conditions. Clustering scores also improved in this condition to support the claim that the children were in fact using the categorization strategy. Returning to percent recalled, there was also a significant interaction between Memory Instructions and Knowledge List. Performance increased significantly more, given categorization

instructions, on the high knowledge list than on the medium knowledge list. It does not seem to be the case then, that children are equally able to apply a given strategy even if the requisite knowledge is available. Rather, the ability to apply a given strategy seems to be dependent upon the amount of knowledge one has of the domain.

Let me at this point make two brief concluding remarks. First, is appears to be very important to be able to specify the processes that lead to increased memory performance. For example, with Chi's chess study, it might be the case that the children who were experts in chess memorize chess positions better than adults who are novices because of automatic activation of relevant knowledge. The same adults, on the other hand, might have memorized the digits better because of the application of strategic processing. What might be confounded in this study, however, is the use of automatic processing on the part of the children and strategic processing on the part of the adults. What we need are experimental methods to distinguish between these two modes of processing. I have tried to accomplish this by attempting to inhibit strategic processing on the part of the learner. Even under this condition, the same level of performance in the high and the medium knowledge lists is still obtained. This indicates that automatic processing is implicated in mediating better performance on the high list.

Still, as discussed earlier, we know that effective strategic processing also increases memory performance, since when I instructed the children to try and categorize the list performance increased. More importantly, the ability to apply a given strategy depended on the amount of knowledge one had of the items. Adults might perform better

than children on a number of tasks because first, there is a greater amount of automatic processing due to their increased content knowledge, secondly, they have more knowledge of available strategies, and finally, they have an easier time applying the strategies. Given that all three of these factors effect performance, the relative contributions of each, in terms of explaining developmental differences in free recall performance, needs to be teased apart.

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Table 1

Stimulus Materials

CATEGORIES	HIGH	MEDIUM
ANIMALS	HORSE	RABBIT
	PIG	FOX
	DOG	SHEEP
	CAT	GOAT
VEHICLES	CAR	BOAT
	BUS	PLANE
	TRUCK	WAGON
	BIKE	TRACTOR
BODY PARTS	HAND	BACK
	ARM	NECK
	HEAD	KNEE
	LEG	TOE
FURNITURE	CHAIR	STOOL
	TABLE	DRESSER
	COUCH	BENCH
	BED	LAMP
CLOTHING	SOCKS	SCARF
	DRESS	SWEATER
	PANTS	VEST
	SHIRT	BELT
FRUITS	GRAPE	TOMATO
	ORANGE	BERRY
	APPLE	PLUM
	BANANA	LEMON

Percent Recalled As A Function Of
Memory Instructions, Knowledge, and Grade

			Instructions	
Grade	Knowledge	Repetition	Standard	Category
2nd	High	.26	.28	.48
	Medium	.18	.19	.29
5th	High	.36	.40	.61
	Medium	.28	.25	.39